Exploring the Costs and Values of Distributed Resources

Minnesota DG Workshop
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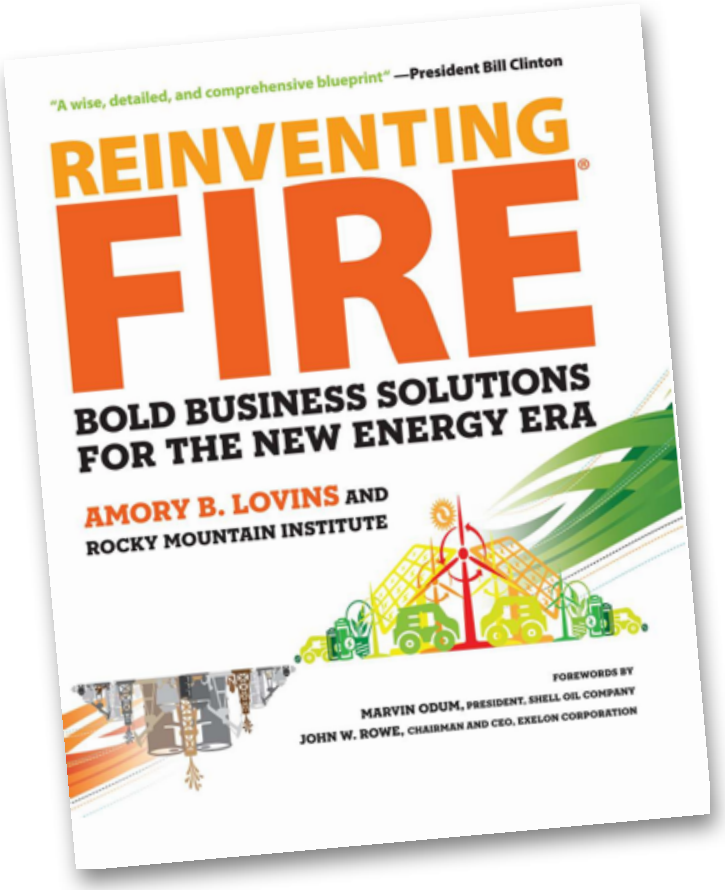
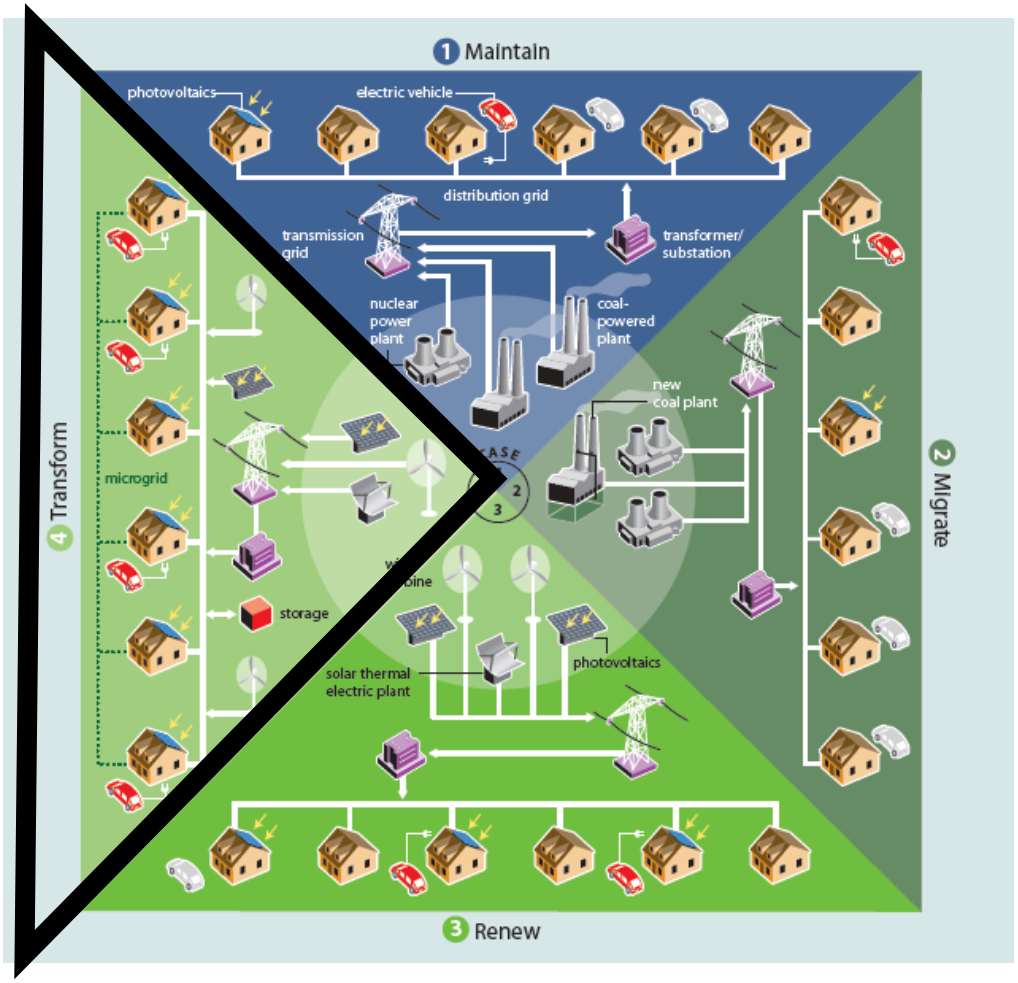
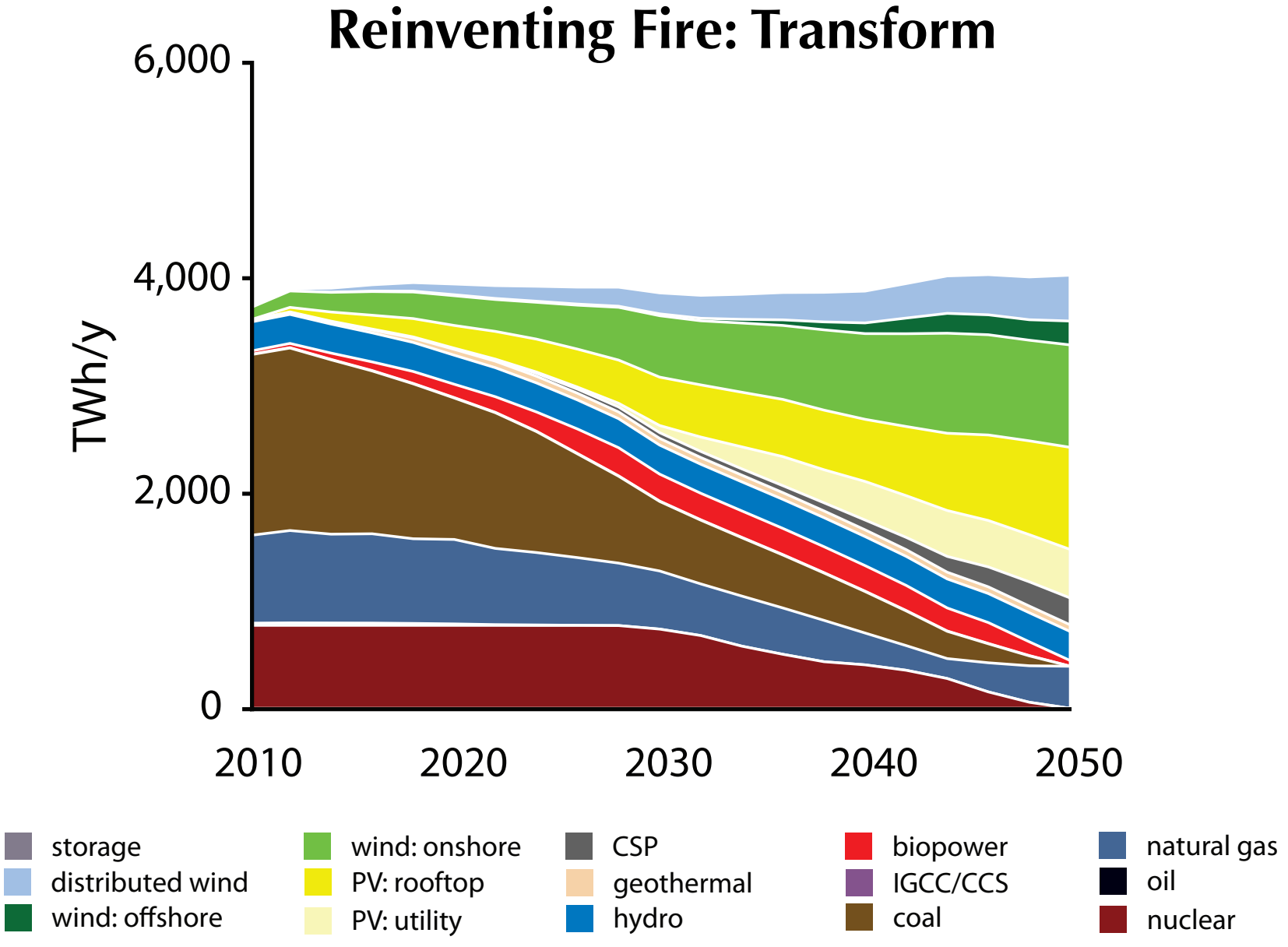
Reinventing Fire: RMI's vision and strategic focus





Reinventing Fire envisions a transformed electricity system based on efficiency, renewables, and distributed resources

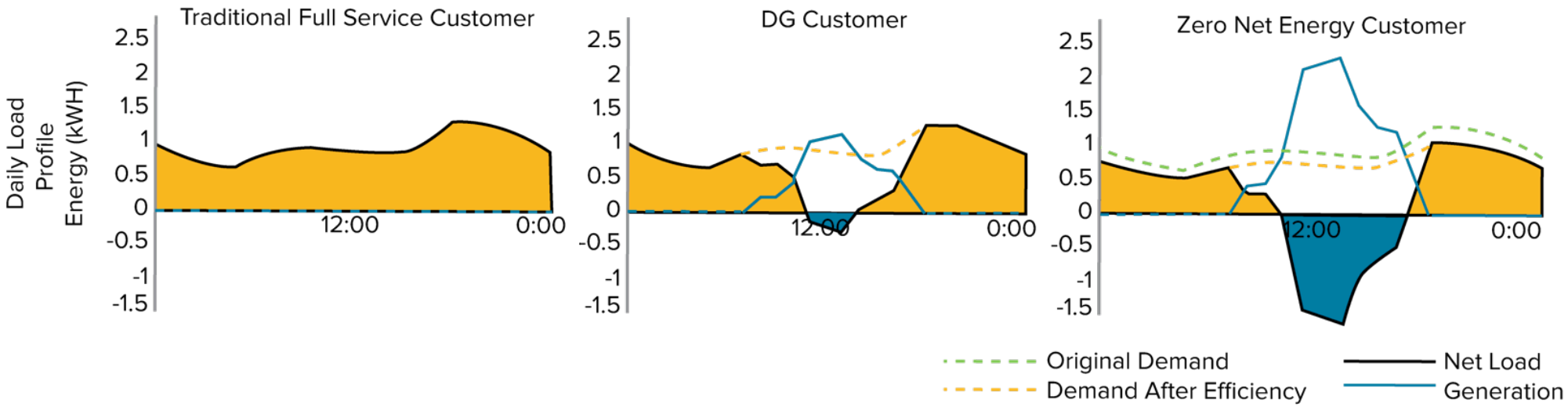


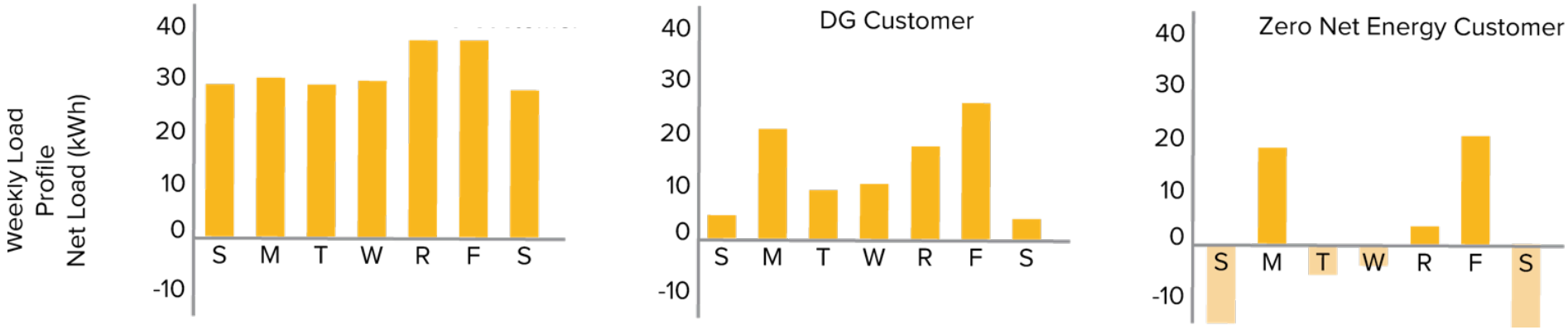
e- Lab Electricity Innovation Lab ROCKY MOUNTAIN INSTITUTE

ACCELERATING PRACTICAL INNOVATION

Given current regulatory and institutional structures, distributed resources result in important misalignments between actors

CUSTOMERS WITH DISTRIBUTED GENERATION DIFFER IN THEIR SERVICE NEEDS FROM FULL-SERVICE CUSTOMERS





If Left Unaddressed, the Disconnect Between Service and Value Flows Will Create Misaligned Incentives

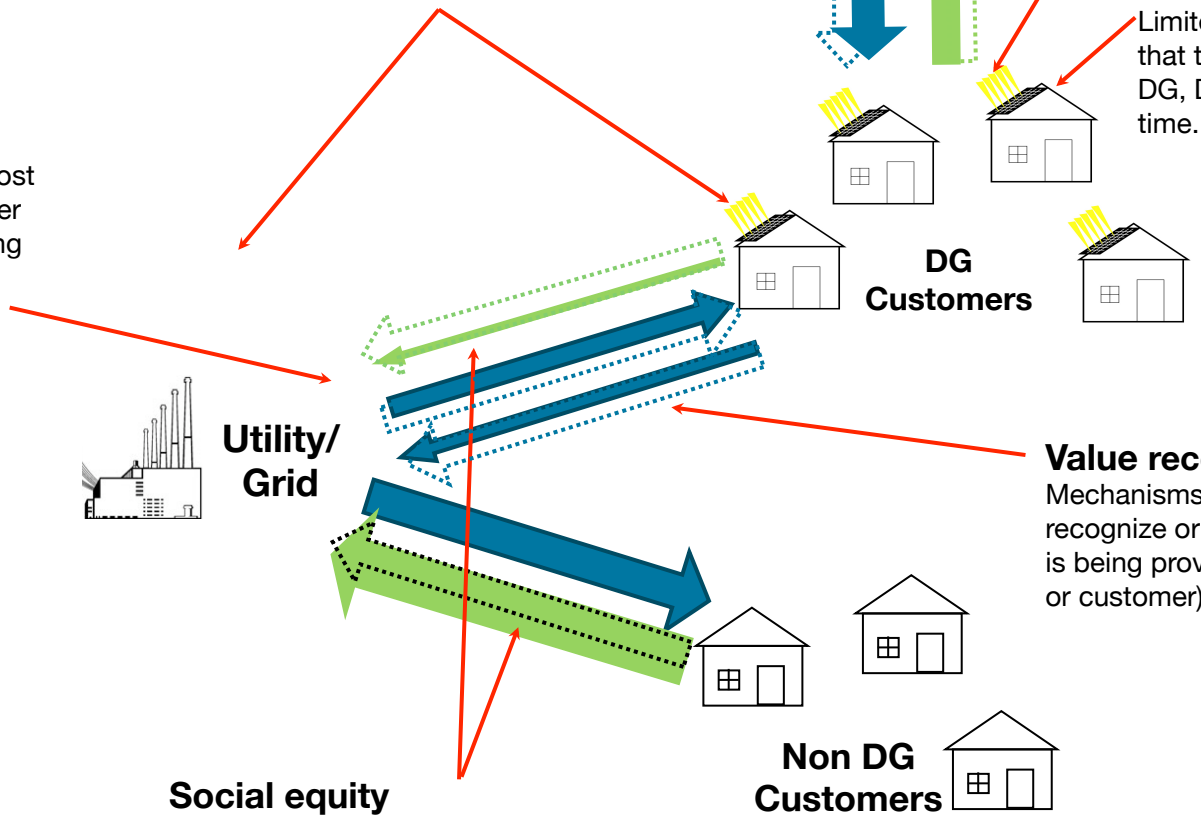
DG and DSM service providers

Flexibility and Predictability
Providing reliable power requires grid flexibility and predictability. Power from distributed renewables fluctuate with the weather, adding variability, and require smart integration to best shape their output to the grid.

Social priorities
Society values the environmental benefits that distributed renewables provide, but utility has little incentive to encourage it due to rate impacts.

Location and Time
Limited feedback loop to customers that the costs of service and value of DG, DR and EE vary by location and time.

Cost allocation
To the utility, revenue from DG customers may not match the cost to serve those customers. Further the cost of integration—balancing supply and demand—is not transparent.

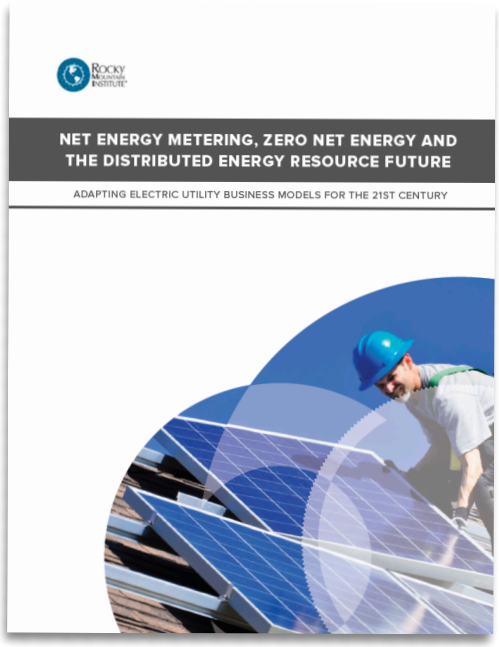


Value recognition
Mechanisms are not in place to recognize or reward service that is being provided by actor (utility or customer).

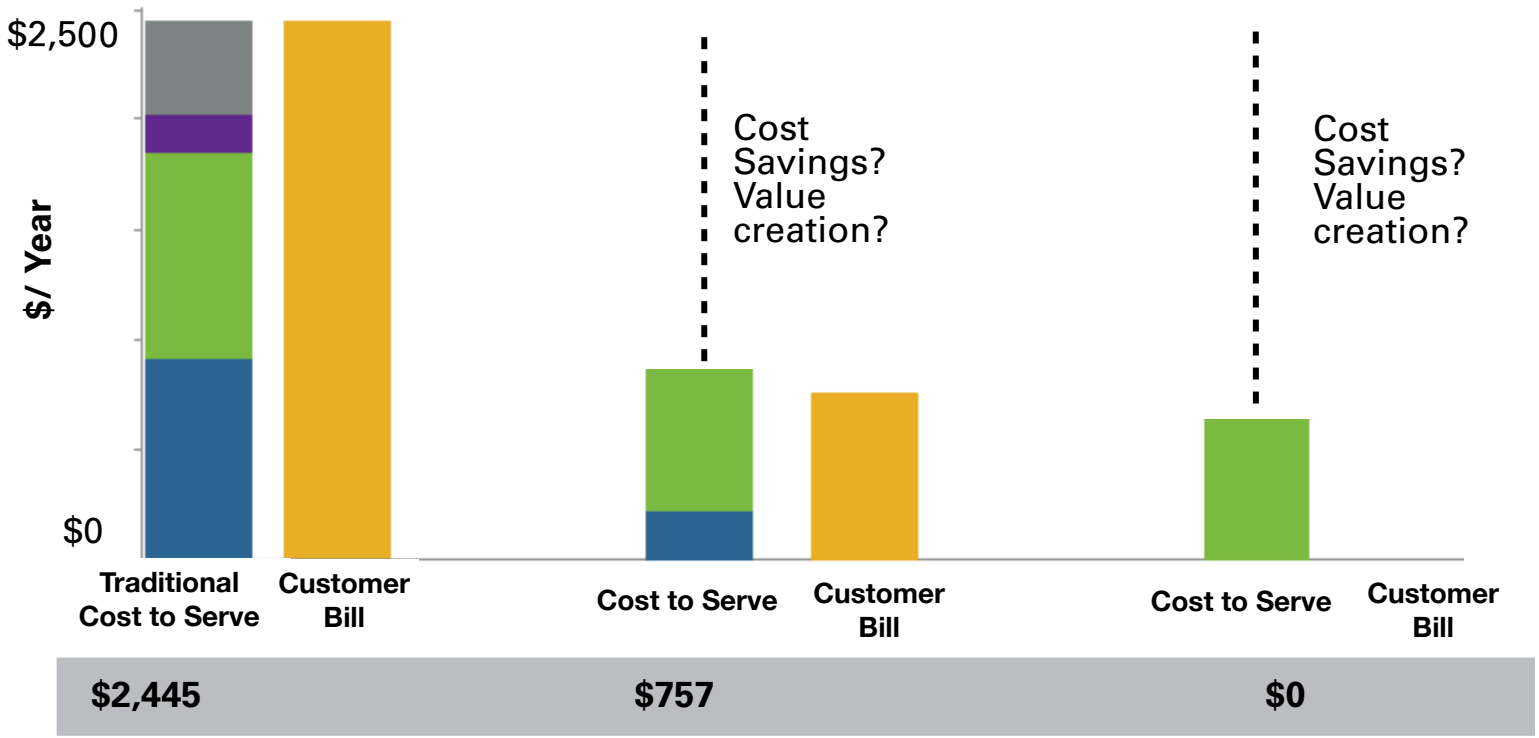
Social equity
Costs not paid for by DG customers are allocated to non-DG customers

$$ service

THESE MISALIGNMENTS ARE COMING TO A HEAD IN CALIFORNIA—IMPORTANT TO FOLLOW, BUT BEWARE OF TRANSLATING TO OTHER PLACES TOO LITERALLY



Illustrative Impacts Under Current Rate Structures

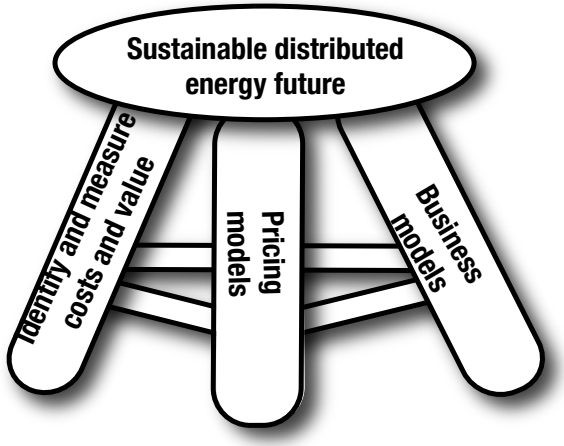


Generation Cost
Distribution Cost
Transmission Cost
Other Costs

RMI, PG&E NEM & ZNE report

To find a sustainable path forward, three related issues must be addressed

Accurately identify and evaluate the costs and values of distributed resources

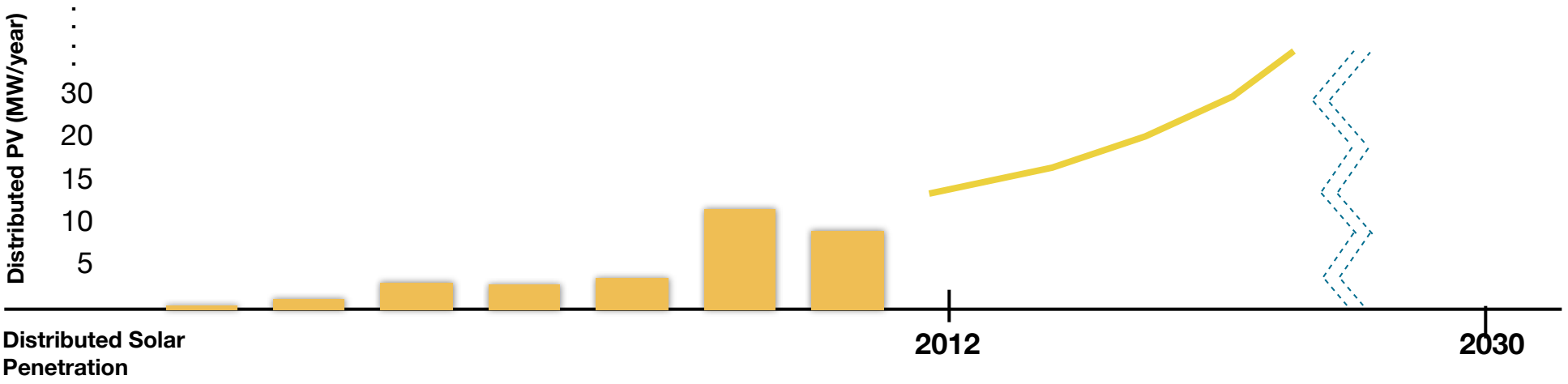


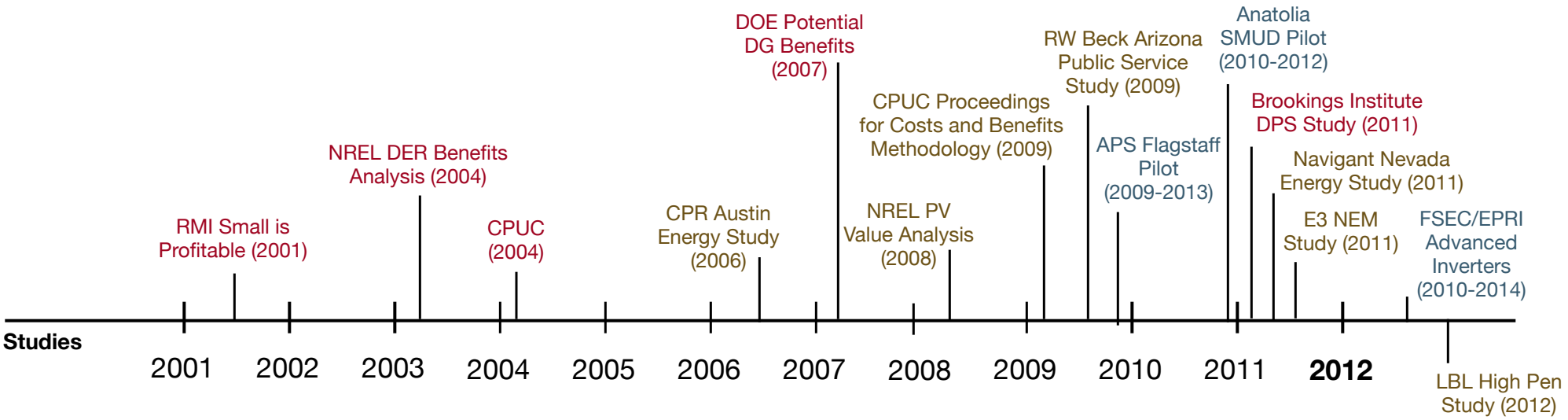
Remedy misalignments through sustainable pricing models

Adapt utility business models to create and sustain value

The costs and values of distributed resources are actively being explored, but important gaps remain

RMI REVIEWED ~30 STUDIES OF THE COSTS AND VALUES OF DISTRIBUTED RESOURCES



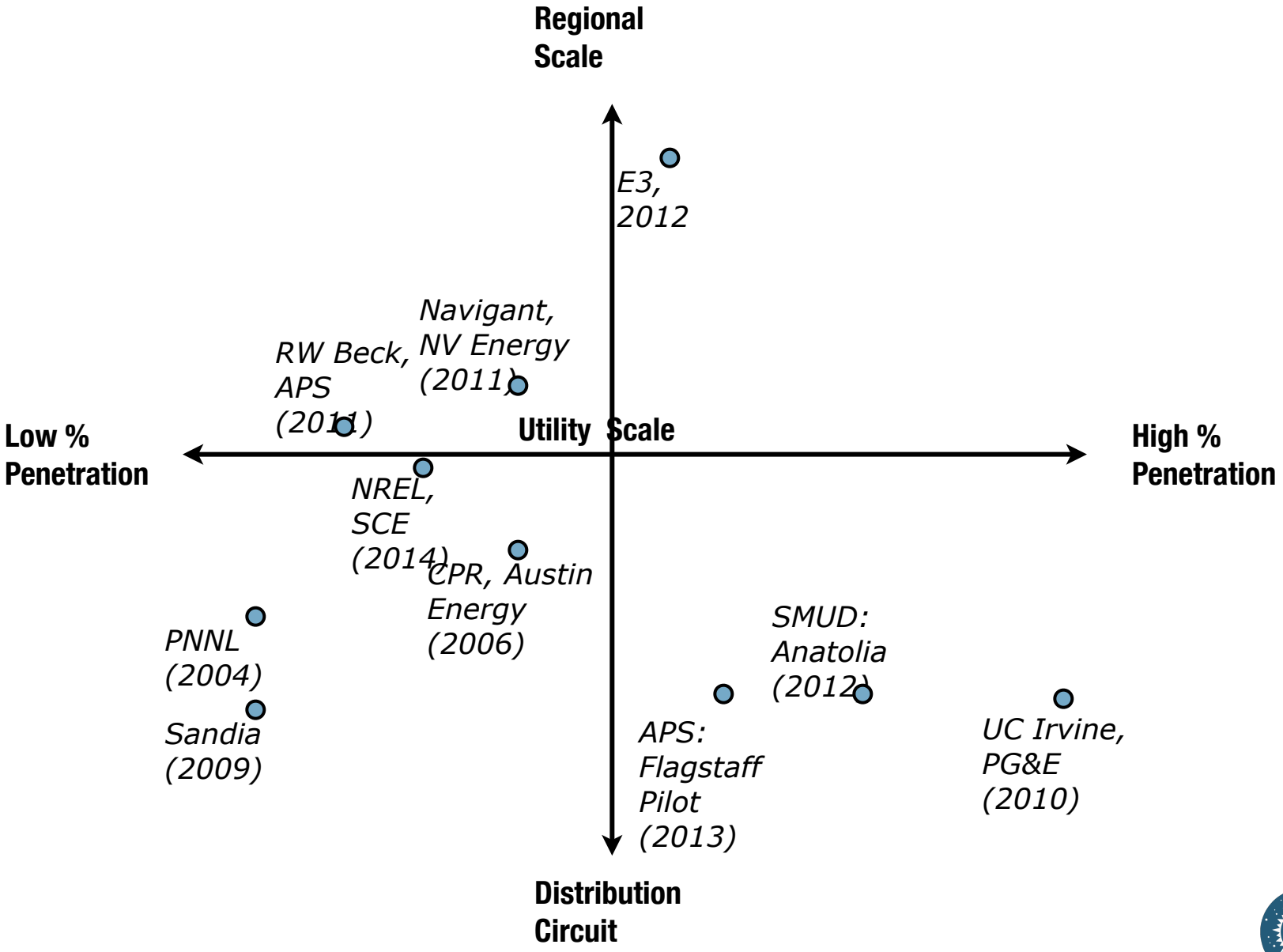


Theoretical Framework
Overview of the types of impacts from distributed energy resources.

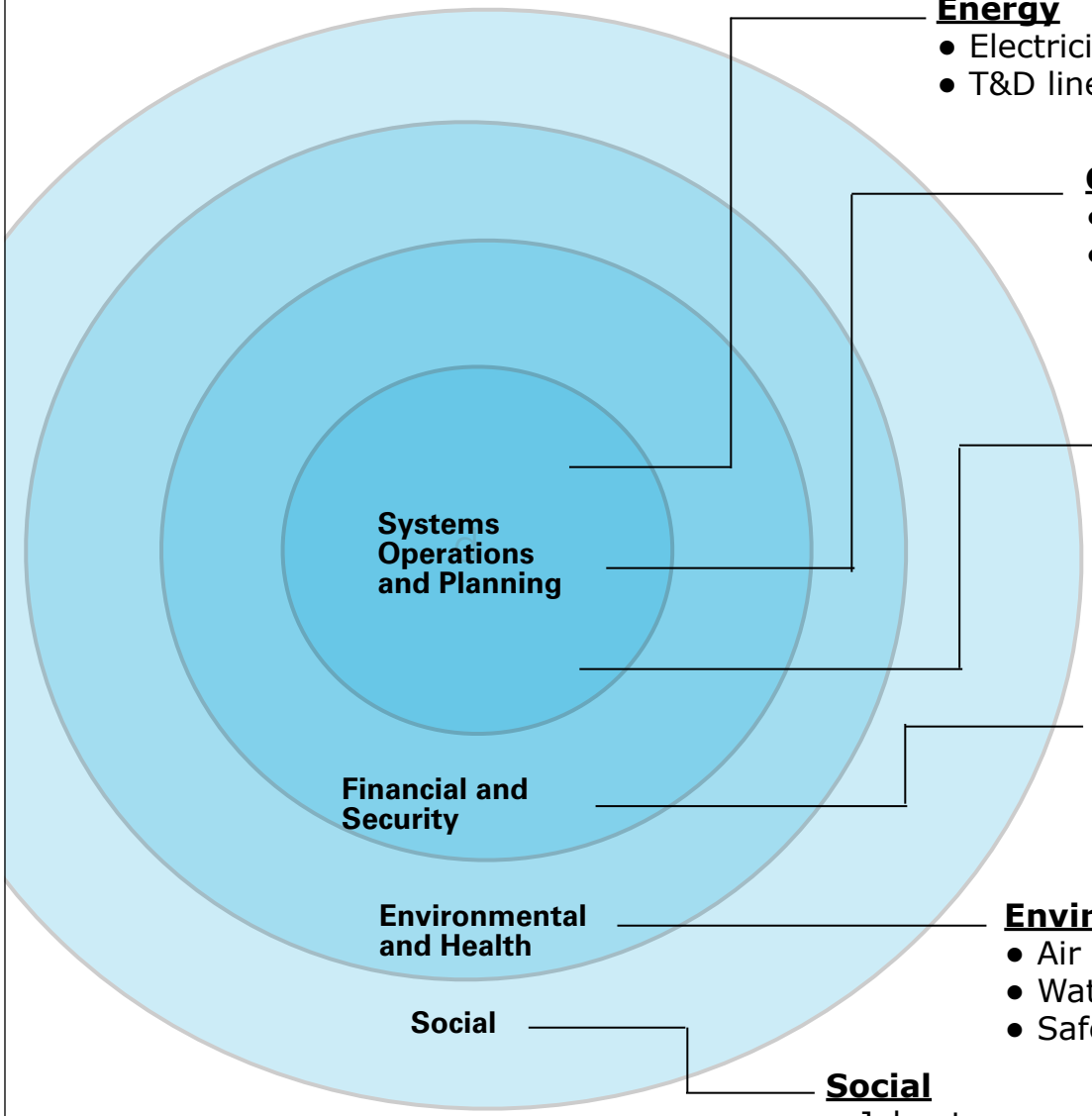
Quantitative Analysis
Approach to value known impacts of PV.

Pilot Projects
Technical projects that test the existence and magnitude of emerging impacts.

MOST STUDIES HAVE LOOKED AT LOW TO MEDIUM PENETRATION AND INDIVIDUAL DISTRIBUTION CIRCUITS



THERE ARE MANY SOURCES OF COST AND VALUE THAT SHOULD BE CONSIDERED, BUT USUALLY ONLY A FEW ARE



Energy
- Electricity
- T&D line losses

Capacity
- Generation assets
- T&D upgrades

Grid Support
- Reactive power
- Voltage control
- Frequency regulation
- Energy imbalance
- Operating reserves
- Scheduling/forecasting

Financial and Security Risk
- Fuel and electricity price volatility
- Option value & modularity
- Emergency power supply

Environmental and Health
- Air impacts (CO2, SOx, NOx, PM10)
- Water and land impacts
- Safety

Social
- Jobs, taxes, market/community transformation, etc.

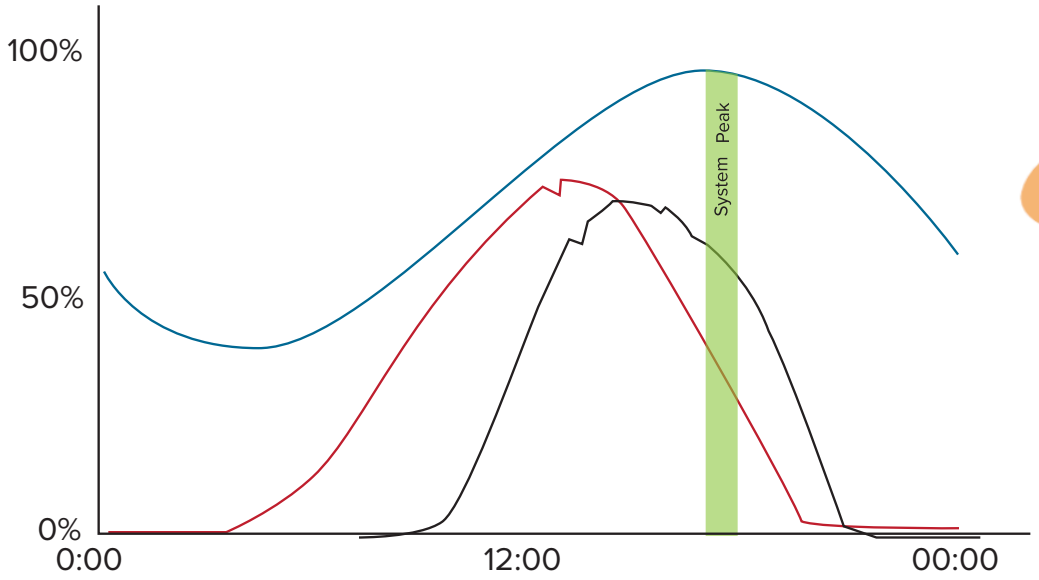
DISTRIBUTED RESOURCES CAN PROVIDE VALUE AT THE "RIGHT PLACE, RIGHT TIME"

- Costs and benefits are highly variable and non-linear in nature
- Dependent on the coincidence of DG production to the needs of the rest of the system

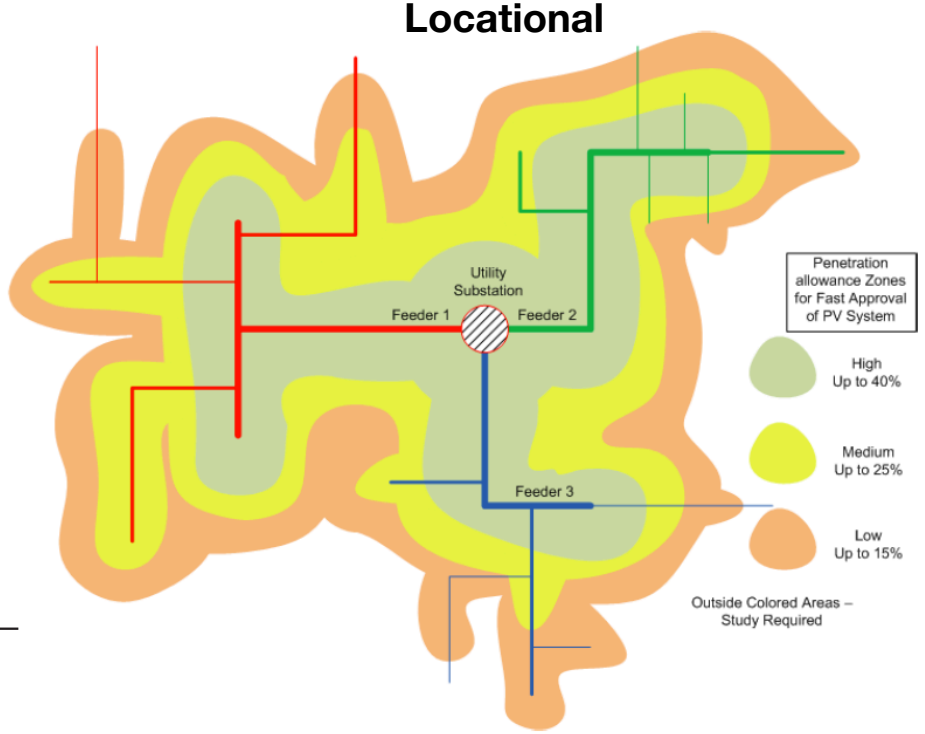
Factors that affect value:

- flexibility
- predictability
- controllability
- timing
- location

Temporal

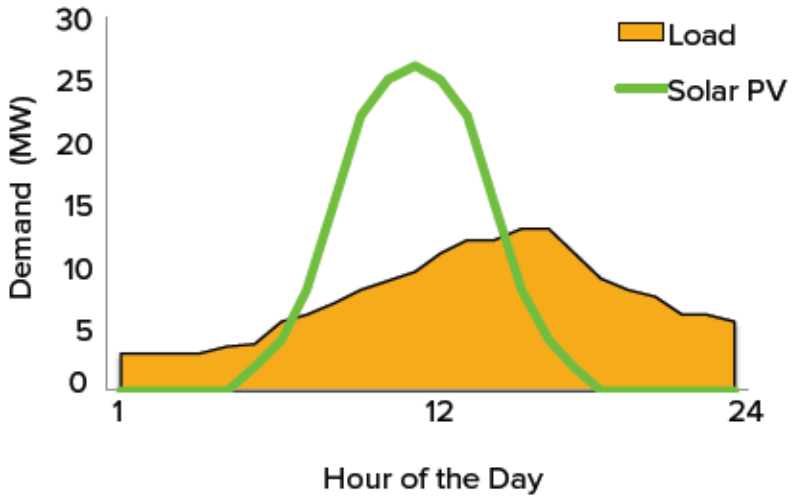


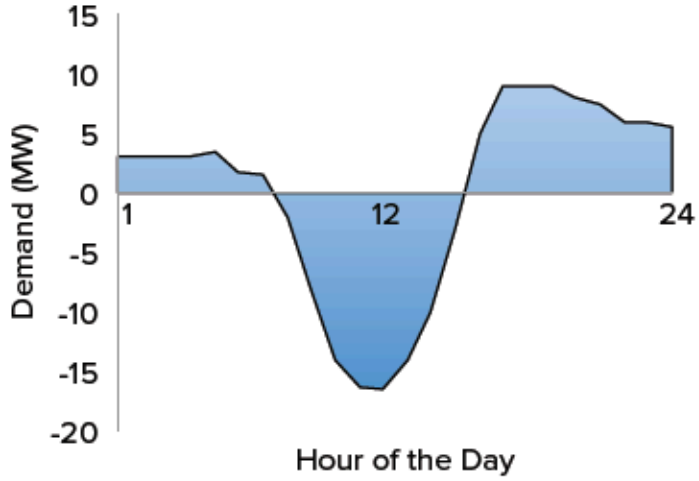
Locational



WITH THE RIGHT TECHNOLOGY AND PRICING SIGNALS, COST TO THE SYSTEM CAN BE MINIMIZED AND VALUE MAXIMIZED

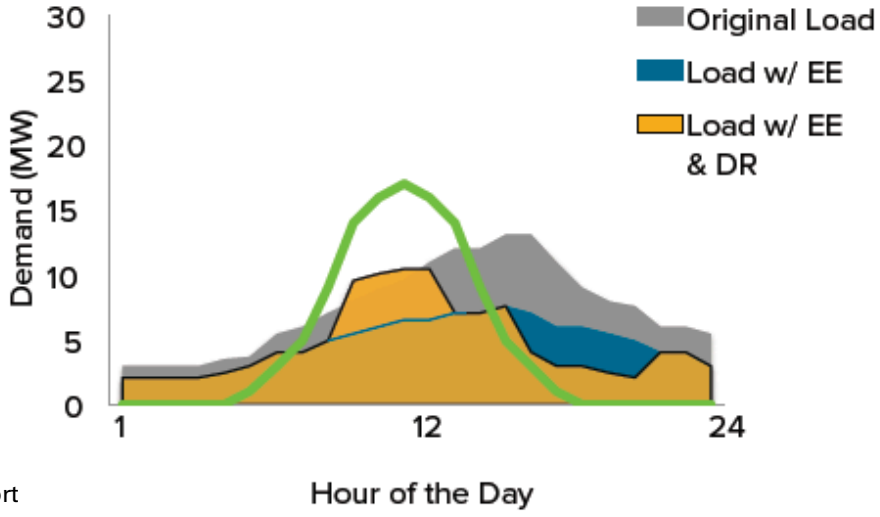
Solar PV 25 MW

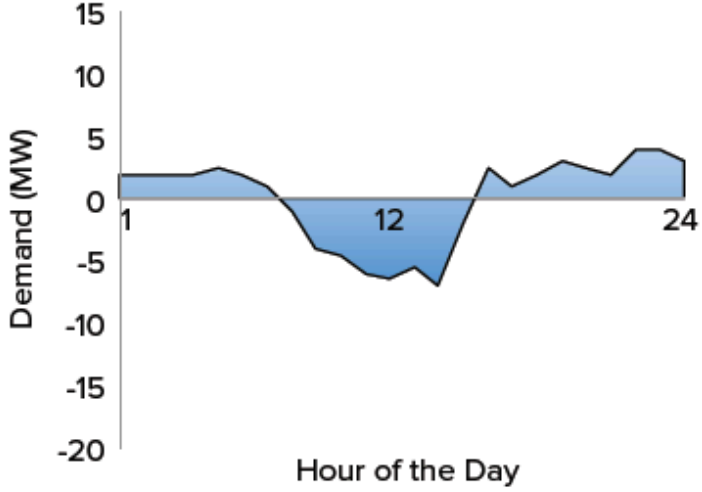




Energy Efficiency, Demand Response, then Solar PV

Peak grid use 10 MW





RMI, PG&E NEM & ZNE report

KEY ISSUES THAT ARISE

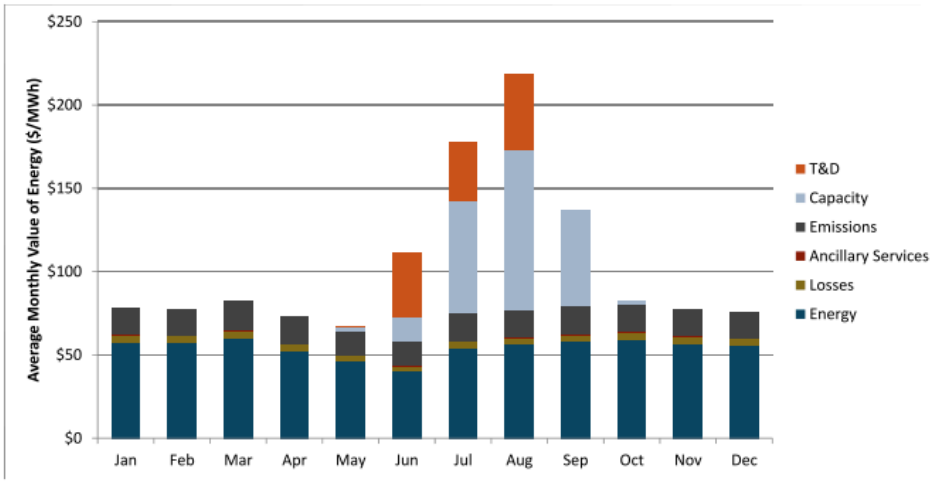
- What grid services do distributed resources require, and which can they provide?
- What is the total cost/value that could be captured?
- How might costs/values change with increasing penetration?
- What about location and timing?
- What kinds of pricing mechanisms can most accurately reflect that value?

Spotlight: Interesting Goings-On

LEADING MODELS HAVE MADE PROGRESS, BUT THERE IS A NEED TO EXPLORE COSTS & VALUES OUTSIDE SYSTEM OPERATIONS & PLANNING

E3 Model

Figure 2. Average monthly avoided cost in CZ13 in 2017



CPR Model

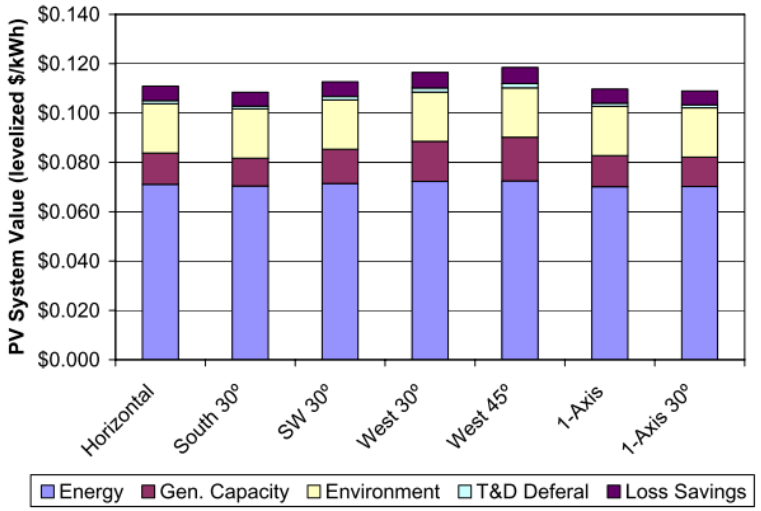
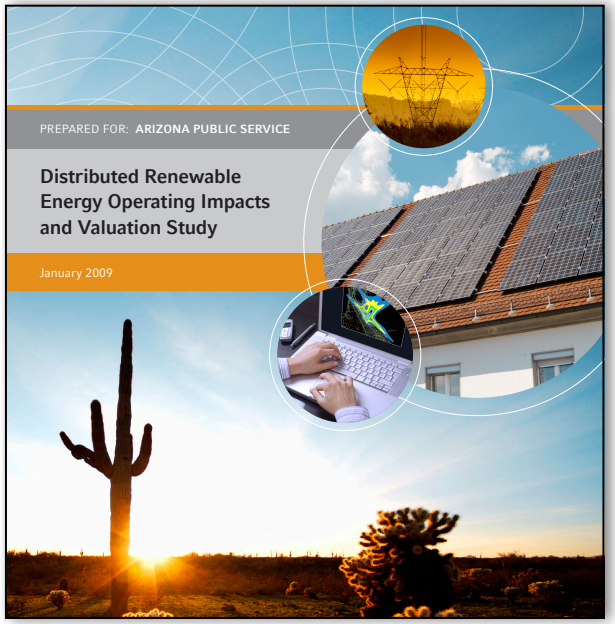


Figure 16. Levelized value by PV configuration ($/kWh).

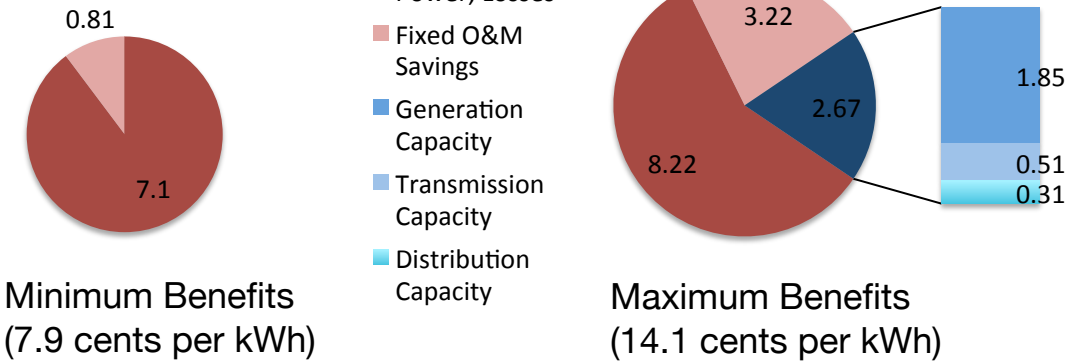
Degree that Cost/Value is Adequately Addressed

Cost/Value Category	E3	CPR
System Operations (avoided electricity, T&D line losses)	🟢	🟢
System Planning (generation capacity, T&D capacity)	🟢	🟢
Grid Support Services (DG provision and requirements for ancillary services)	🟡	🔴
Financial and Security (fuel price volatility and resilience)	🔴	🟡
Environmental (air, water, and land impacts)	🟢	🟡
Social (program costs, job creation, etc)	🔴	🟡

ARIZONA PUBLIC SERVICE: CHANGING VALUE OVER TIME



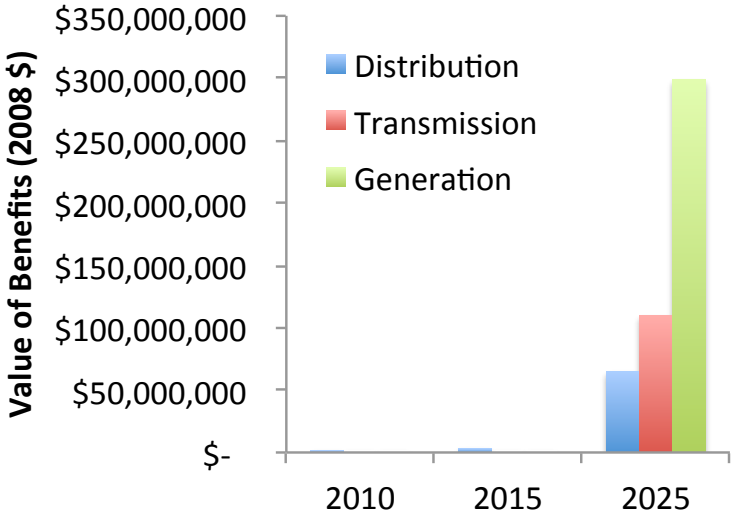
Total Benefits from Distributed Solar in 2025 (cents/kWh)



Minimum Benefits
(7.9 cents per kWh)

Maximum Benefits
(14.1 cents per kWh)

Capacity Benefits



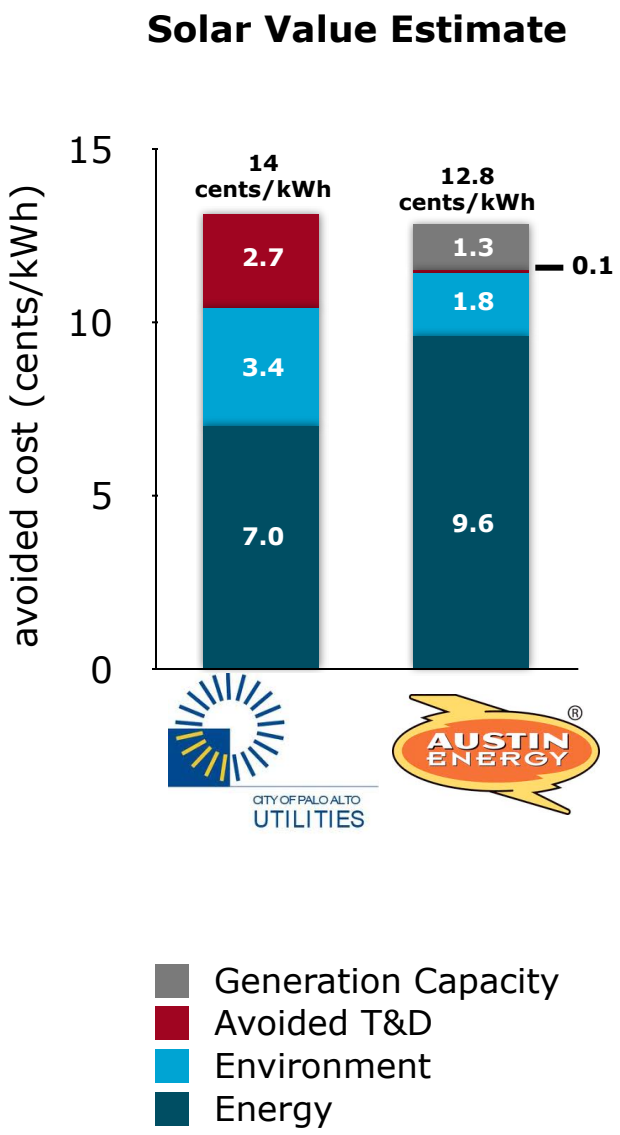
RW Beck, APS Study

NREL: WIDE RANGE OF VALUES BASED ON KEY DRIVERS

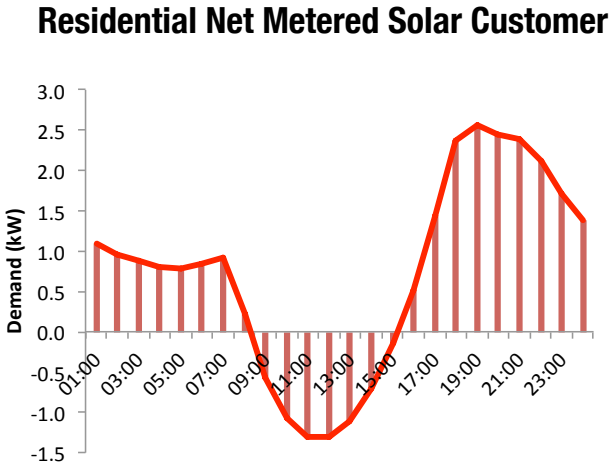
PV Values		Customer/ Participant (cents/kWh)	Utility/ Ratepayers (cents/kWh)	Society (cents/kWh)	Net (cents/kWh)	Value Drivers
Benefits	Central Power Generation Cost		3.2 - 9.7		**3.2 - 9.7**	Gas price, heat rate
	Central Power Capacity Cost		1.1 - 10.8		**1.1 - 10.8**	ELCC, gas turbine capex, life adjustment
	T&D Costs		0.1 - 10.0		**0.1 - 10.0**	Location, growth, climate
	System Losses		0.5 - 4.3		**0.5 - 4.3**	Location, time period, other benefits
	Ancillary Services		0 - 1.5		**0 - 1.5**	Ancillary service prices, voltage support
	System Resiliency		Low		**Low**	Quantification methodology unclear
	Hedge Value		0 - 0.9		**0 - 0.9**	Gas price forecasts, futures, heat rate
	Market Price Impacts/Elasticity		Low		**Low**	Quantification methodology unclear
	Customer Price Protection	0.5 - 1.0			**0.5 - 1.0**	Calculation method
	Customer Reliability	Low			**Low**	Quantification methodology unclear
	Criteria Pollutant Emissions			0.02 - 2.0	**0.02 - 2.0**	Market value of emissions
	Greenhouse Gas Emissions			0.002 - 4.2	**0.002 - 4.2**	Reduction costs, market value, discount rate
	Implicit Value of PV			0 - 2.0	**0 - 2.0**	Customer willingness to pay premium
Costs	Equipment and Installation	(47) - (19)			**(47) - (19)**	Size, location
	PV O&M Expenses	(0.15) - (0.05)			**(0.15) - (0.05)**	Type of system
	Benefits Overhead		(0.2) - (0.1)		**(0.2) - (0.1)**	Infrastructure and administration costs
Transfers	PV Owner Electricity Bill	1.1 - 33.0	(33.0) - (1.1)		**-**	Customer type, rate structures, load profile
	Federal Incentives	1.58 - 7.95		(7.95) - (1.58)	**-**	Customer type, size, cap
	State Incentives	0 - 17.8		(17.8) - 0	**-**	State, customer type, size, production, cap
Shareholder Total		(43.97) - 40.7	(28.3) - 36.0	(25.7) - 6.6	**(41.9) - 27.3**	

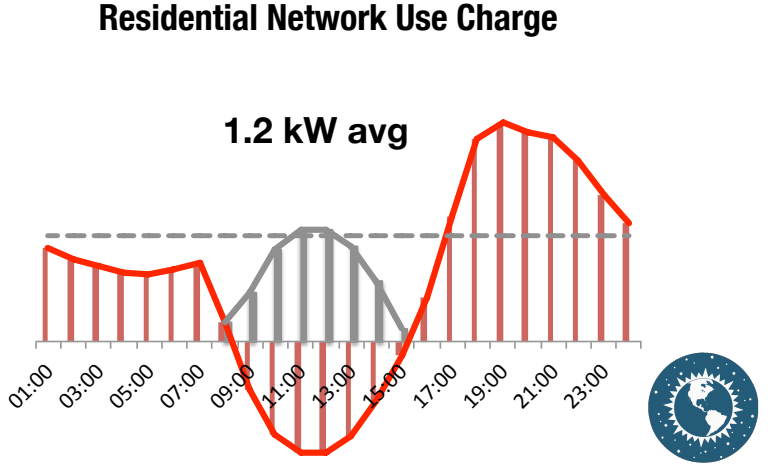
Photovoltaics Value Analysis Report, NREL, 2008

UTILITIES ARE ACTIVELY EXPLORING ALTERNATIVE PRICING MODELS TO REFLECT THE COSTS AND VALUES OF DISTRIBUTED RESOURCES



SDGE
A Sempra Energy utility





KEY TAKEAWAYS

- Distributed resources can incur cost or provide value to the electricity system
- It's critical to understand and adequately calculate the magnitude and key drivers of those costs and values; such an assessment provides the foundation for pricing and business model design
- Price signals and incentives could direct distributed resource investment for greatest system benefit and uncover new sources of value
- These issues will become increasingly important as more investment is made outside of the utility's control
- There will always be tension between rate simplicity, the need to support energy efficiency and customer generation, and the need for accurately allocating benefits and costs

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